



EVALUATION THE EFFECT OF TITANIUM CONTENT ON 2024 ALUMINUM ALLOY-1.5% CARBON NANOTUBE COMPOSITE

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ABSTRACT

Aluminum alloy 2024 is widely used in frame of aircraft. Carbon Nanotubes (CNTs) used recently as a reinforcement material for 2024 aluminum alloy. In this research 2024-1.5% CNTs hybrid composite was prepared by traditional casting. Titanium (Ti) was added in (0.2, 0.4, 0.6 and 0.8%) to 2024-1.5% CNTs composite. The chemical composition was investigated by optical emission spectroscopy (SPECTROMA). Scanning electron microscope and light optical microscope were used for microstructure examination. EDS used for evaluation of phases and intermetallic compounds. The microscopic examination showed that the grain size decreased with increasing Ti content in presence of CNTs and the microstructure be more regular with increasing Ti content. The EDS results that intermetallic compounds and phases precipitated at the grain boundaries and near grain boundaries.

Key words: Aluminum alloys, AA2024, carbon Nanotube, precipitation, aerospace.

Cite this Article: Talib Abdulameer Jasim, Hussein F. Mahdy, Ahmed Saleh Al Graite, Ali H. Hallem, Evaluation the Effect of Titanium Content on 2024 Aluminum Alloy-1.5% Carbon Nanotube Composite, *International Journal of Mechanical Engineering and Technology* 10(1), 2019, pp. 89–96.

<http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=10&IType=1>

1. INTRODUCTION

The using of pure aluminum remains Very limited in engineering applications as it Soft and Low mechanical properties. Therefore, many researchers have consistently improved aluminum alloy since many decades [1, 2, 3].

Researches have been directed towards improving the mechanical properties of aluminum by means of mechanical formation (thickening) or by adding special elements such as copper, semiconductors, zinc, magnesium and nickel, and then improve the mechanical properties by solution heat treatment and aging. M. O'Donnell, etal, study the effect of pre-strain and solution heat treatment on the formability of a 2024 aluminium alloy. The concluded results were the best formability is 8 % at annealing temperature and 8 % solution heat treatment, whereas the worst occurs for the 4 % at annealing and 4 % SHT [4].

The mechanical properties of Al 2024 based hybrid metal composites was evaluated by Preetam Kulkarni. The researcher use glass fiber and fly ash for reinforce the 2024 alloy. The concluded results were, the ultimate tensile strength and compression stress increased with increasing e-glass content in alloy [5]. Caleb Carreño-Gallardo, et al, [6] studied the microstructure and mechanical properties of Al2024/B4C composites prepared by mechanical milling and conventional sintering, followed by a T6 heat treatment. They concluded that, the B4C and milling time improve the mechanical properties of composite. Jufu Jiang et al. [7] studied the effect of Al₂O₃ Nanoparticles on mechanical properties of 2024 aluminium alloy. They concluded that, the stirring temperature and volume fraction of Al₂O₃ Nanoparticles were effect on mechanical properties of the alloy.

Influence of Matrix Alloy and Si₃N₄ Nanoparticle on Wear Characteristics of Aluminum Alloy Composites was studied by V. K. Reddy and A. Chennakesava Reddy [8]. They deduced that, the increasing of Si₃N₄ nanoparticles content increases the wear resistance of composite alloy.

The aim of this study is to evaluate the effect of Titanium content on microstructure and some mechanical properties of 2024 aluminum alloy-1.5% Carbon Nanotube composite as cast.

2. EXPERIMENTAL SETUP

Experimental work was carried out by production the alloys by traditional casting. The alloys were prepared by adding the alloying elements to aluminum according to 2024 aluminum alloy standard. 1.5% multi wall carbon Nanotubes (CNTs) of (20-30 nm length) was added to four alloys. Titanium (Ti) was added to alloys (S0, S1, S2, S3, and S4) in content (0, 0.5, 1, 1.5, and 2% respectively). After casting, samples were prepared for microstructure according to samples preparation standards. Samples were prepared for examination by (Tescan Vega 3 SEM and EDX) scanning electron microscope (SEM) and energy dispersive spectrometer (EDS) examination. The chemical composition of alloys was performed by optical emission spectrometer type (SPECTROMA) as in table 1.

Table 1 Chemical composition of fabricated alloys

Sample No.	Cu%	Mg%	Mn%	Fe%	Si%	Zn%	Cr%	CNTs%	Ti%	Al%
S0	4.552	1.283	0.581	0.528	0.552	0.280	0.098	1.465	0.001	Bal.
S1	4.458	1.215	0.556	0.534	0.549	0.271	0.089	1.502	0.479	Bal
S2	4.422	1.218	0.549	0.527	0.546	0.273	0.095	1.468	1.006	Bal
S3	4.499	1.244	0.519	0.507	0.548	0.277	0.099	1.4.89	1.508	Bal
S4	4.550	1.208	0.522	0.520	0.501	0.281	0.078	1.4.84	1.982	Bal

3. RESULTS AND DISCUSSION

The effect of Ti addition to aa2024 - CNTs composite on microstructure was characterized using light optical microscope and SEM.

3.1. Light Optical microscopy

Fig.1 displays the light optical microscope (LOM) images of 2024-1.5 CNTs composite aluminum alloy. Fig. 1A1 corresponds to S0 alloy without Ti addition. As appears in microstructure, the grains was large and non-homogenous. Fig.1A2 represents the microstructure of alloy S1, the composite of AA2024-CNTs with 0.2%Ti. As shown in this micrograph, the grains started to be more homogenous comparing with fig.1A1 and smaller.

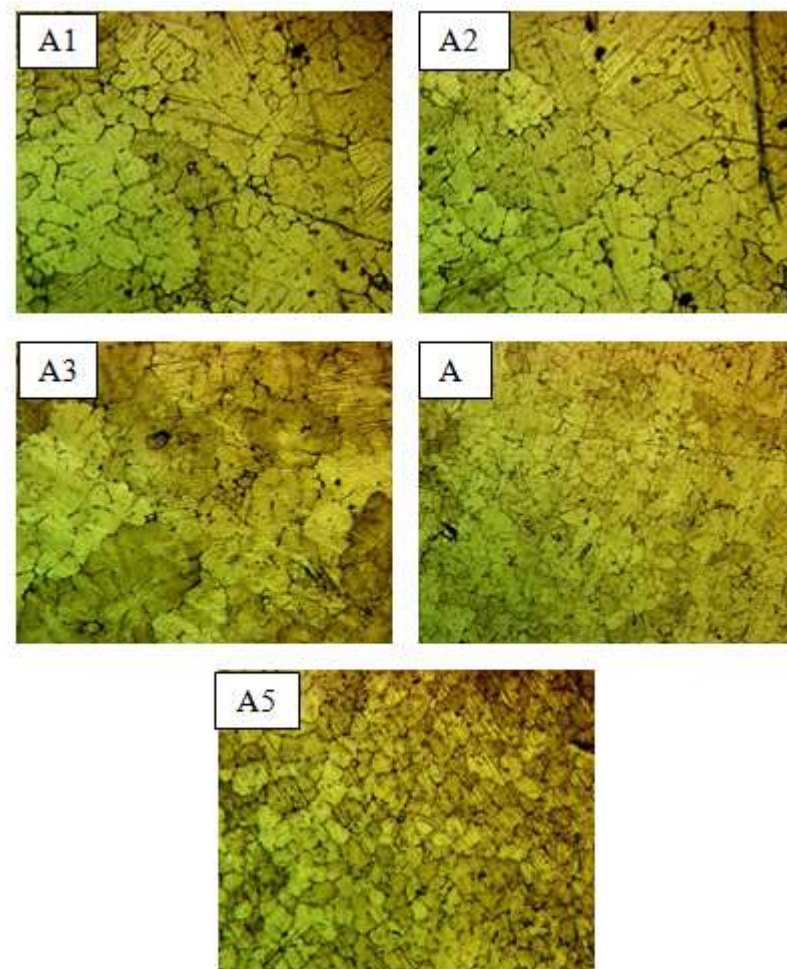


Figure 1: the optical microscopic micrographs of as cast alloys, (A1) the microstructure image of sample (S0), (A2) the micrograph of sample (S1), (A3) the microstructure of sample (S2), (A4) the microstructure of sample (S3), and (A5) the microstructure of sample (S4).

In fig.1A2 the homogeneity of grains increases with smaller size. Fig.1A3 shows the microstructure of alloy S3, the homogeneity increased and the grain size decreased. The most homogenous and smallest grains appear in micrograph in fig. 1A4. It can be deduced from the above, that the rate of homogeneity increases and the grains size decreases with increasing the Ti percentage. The Ti used as a refiner agent for aluminum alloys [9].

3.2. The scanning electron microscopic study

The samples were examined by SEM & EDS to determine the type of compounds and phases. Also to determine the shape of microstructure and effect of titanium content on the size and homogeneity of microstructure .

The SEM images of AA2024-CNTs composite of samples (S0, S1, S2, S3, and S4, were illustrated in fig 2 (a, b, c, d, and e).

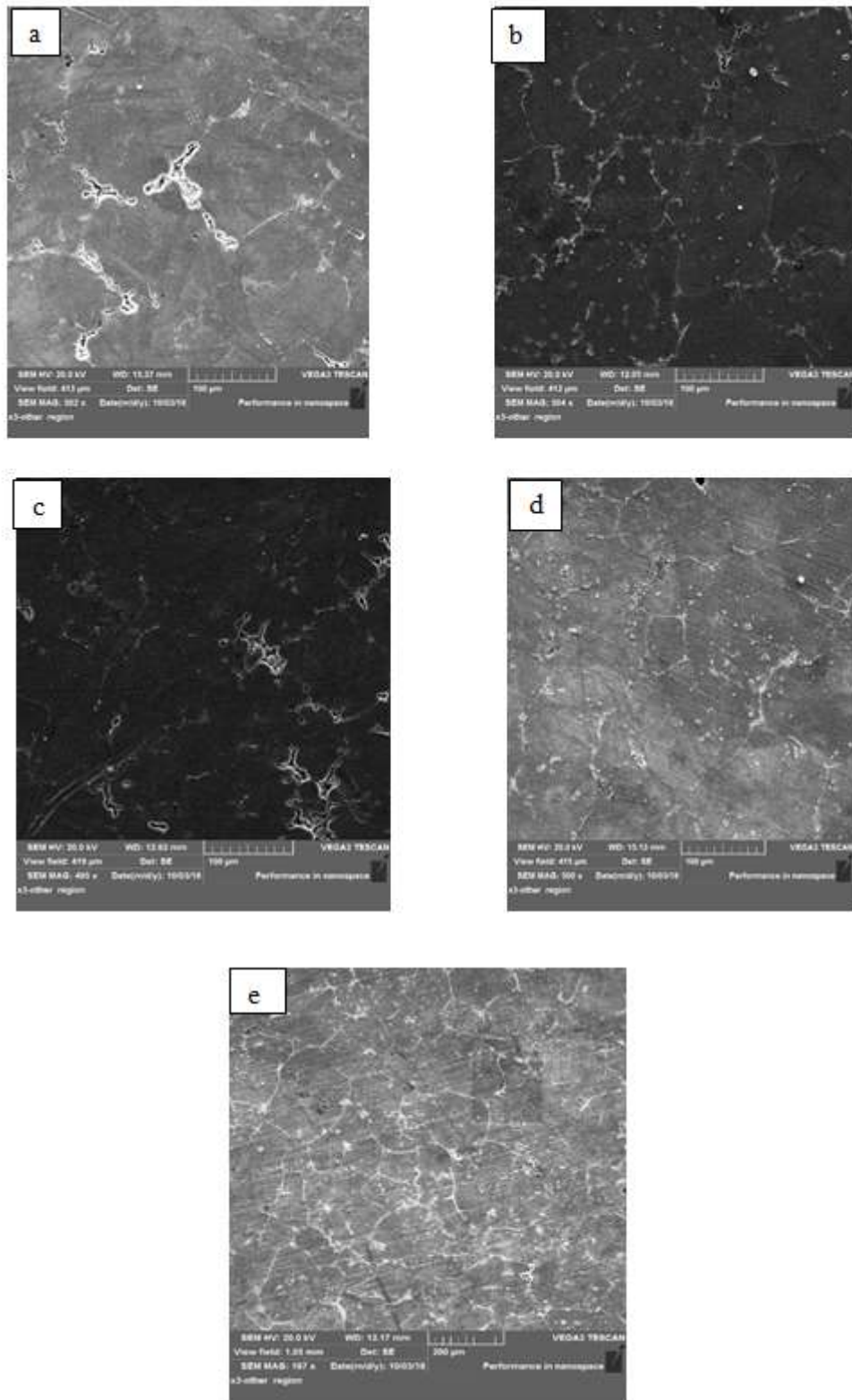


Figure 2 SEM micrographs of as cast alloys, (a) the microstructure image of sample (S_0), (b) the micrograph of sample (S_1), (c) the microstructure of sample (S_2), (d) the microstructure of sample (S_3), and (e) the microstructure of sample (S_4).

In all these micrographs it is clearly appear that many of compounds distributed at grains and grain boundaries. The chemical composition of these compounds and intermetallic compounds analyzed by EDS as illustrated in figs (3, 4 and 5). More over the grains size

decreases and homogeneity of grains increases with increasing the Ti content. The grains size decreases as the result of Ti ability to reduce the size of grains which increases the nucleation of embryos during casting and reduces the grain growth. Fig.3a displays the SEM micrograph of composite of 2024-CNTs aluminum alloy near and in grain boundaries .

Fig.3b, fig.3c and 3d show the composition near the grain boundary region 3, 4 and 5 respectively.

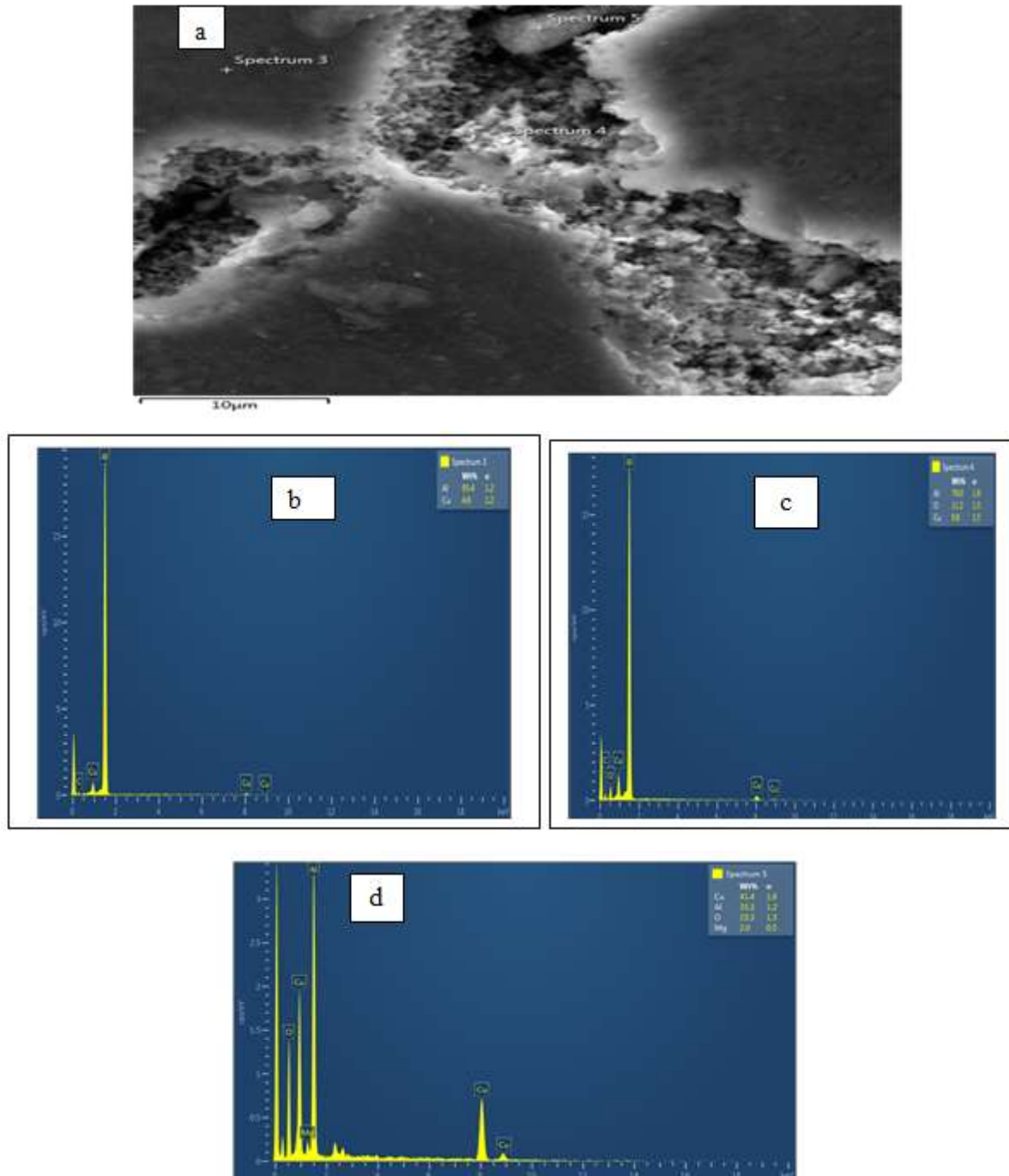


Figure 3 the SEM image and EDS analysis of grain boundaries and near grain boundaries . Fig. 3a the SEM image of near and grain boundaries in regions, fig. 3b, 3c, and 3d EDS analysis of these regions.

The composition mentions that the (Al₂Cu) phase and Al-C compound (Al₄C₃) phase are appears in near and grain boundary.

As shown in fig. 4(a, b and c) the microstructure and composition of compound at 6 and 9 at faraway and edges of grains respectively. Fig. 4b displays (Al-Cu-Mg) at point 6. The edges of grains shows another compounds (Al-Cu-Si) and (Al-C). At the grain boundaries some Al-Cu-Mg-C-O compounds were distributed, may be MgAl₂O₃ and Al₄C₃ as mentioned by Jiang et.al [10].

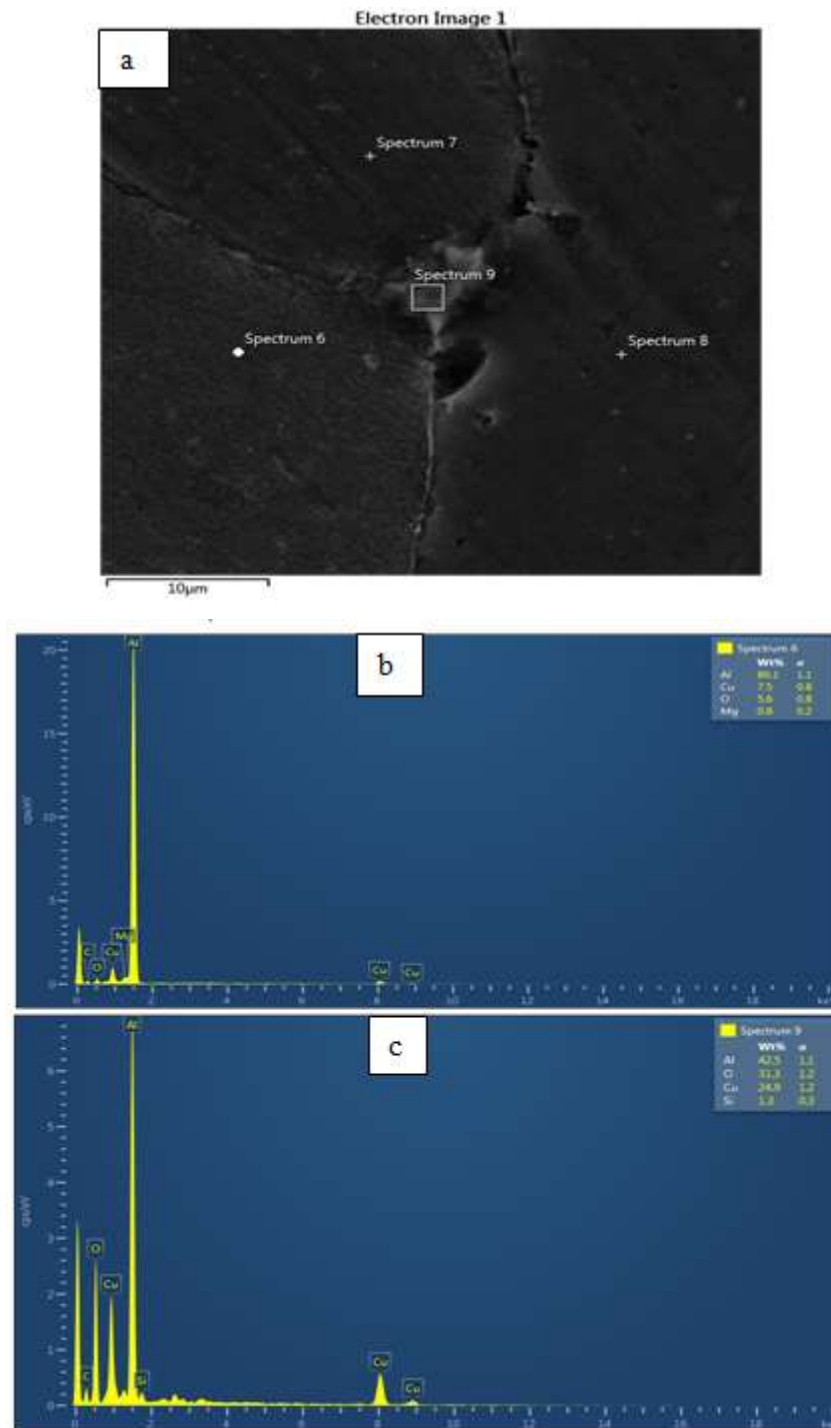


Figure 4 SEM image and EDS analysis at regions 6 and 9.

Fig.5 displays the map of sum spectrum at a large area of grain boundary region. Fig.5a shows the EDS micrograph at a large area at a connection region of grains. Fig.5b displays the composition of this region. C, Ti, Mn, Mg, Cu, O, and Al are as intermetallic and phases. Al_3Ti intermetallic compound precipitates when Ti added in small quantities to aluminum alloys [12]. This intermetallic compound precipitate as a small ceramic particles. Also $(\text{Al},\text{Si})_3\text{Ti}$ phase may be precipitates as Ti added to 2024 aluminum alloy[12-14].

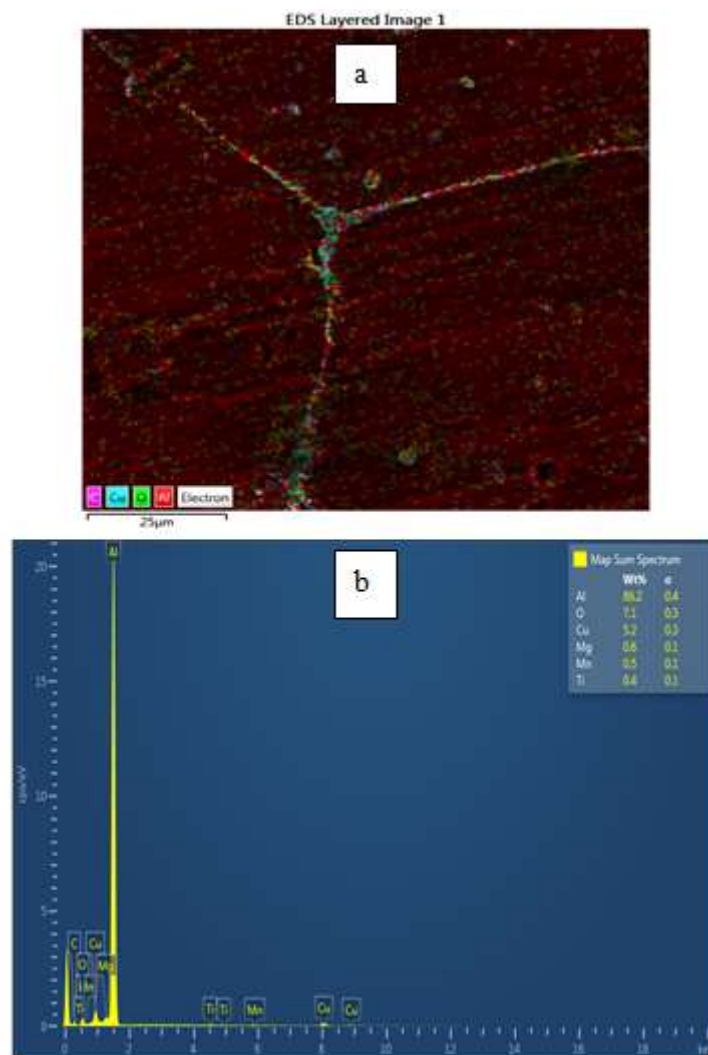


Figure 5 Map Sum spectrometer

5. CONCLUSIONS

The summary of the influence of Ti and CNTs on microstructure of aluminum2024-CNTs composite are:

- The grains size decreases and homogeneity of grains increases with increasing Ti content to 0.8% in presence of NCTs in 2024 aluminum alloy.
- The CNTs distributes as Al_4C_3 at near and grain boundaries.
- Ti addition to aluminum alloys act as a refiner element.
- $(\text{Al},\text{Si})_3\text{Ti}$ phase and Al_3Ti intermetallic compound precipitate as a result on presence of Ti as alloying element in 2024 aluminum alloy.

- MgAl_2O_3 and Al_4C_3 phases precipitate at the grain boundaries.

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